High Temperature Materials Laboratory

Lubrication Challenges for the Hydrogen-Fueled Internal Combustion Engine

Background

The use of hydrogen as a primary fuel for internal combustion engines (ICEs) presents numerous materials challenges. In liquid-fueled engines, the fuel itself provides a measure of lubrication for certain moving parts in the fuel injection system. In the case of hydrogen fuel (where there is no liquid to lubricate parts), however, maintaining adequately low friction and wear is problematic.

Oak Ridge National Laboratory (ORNL) staff (L. Reister and P. Blau) worked collaboratively with Pacific Northwest National Laboratory (PNNL) (J. Holbery) through the High Temperature Materials Laboratory User Program to characterize changes in the structure and properties of sliding surfaces of fuel injectors that were exposed to pressurized hydrogen gas.

The steel fuel injectors were first exposed to pressurized hydrogen for two days in a special autoclave at PNNL. They were then sectioned and brought to ORNL for nanoscale indentation and friction measurements. These tests, and surface topography analysis, were performed on a Hysitron Triboindenter™ in the Friction, Wear, and Machinability User Center.

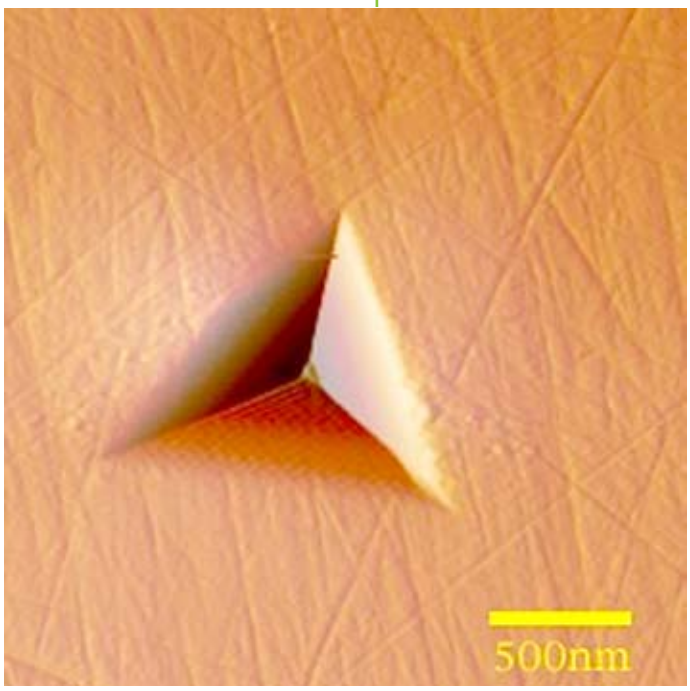

Figure 1. *A 'negative image' of the faceted diamond tip is replicated on this steel surface. The tip can be scanned to generate a surface map or used as a mechanical properties microprobe.*

Technology

The results of this project revealed that exposure to hydrogen environment can change the composition and structure of surfaces of fuel injector plungers sufficiently

Benefits

- Elucidation of technical and scientific challenges of hydrogen internal combustion engines.
- Better understanding of tribophysics of hydrogen exposure in internal combustion engines.

to alter their frictional characteristics. A method had to be developed for mounting the fuel injector parts so that the cylindrical inner bore can be probed with the measuring instrument. Profile scans and nano-scale indentation experiments revealed that friction and surface morphology were indeed affected by hydrogen exposure.

In some cases, the friction was lowered; but in multi-pass experiments, the friction rose.

Tiny hydride crystallites (100 nm to 5 μm across) were detected on the surface of the steel and may play a role in this behavior.

Status

Having established that hydrogen exposure can alter the friction and microstructure of fuel injectors, additional work is being planned to better elucidate the tribophysics of hydrogen exposure and its implications for enabling the technology of hydrogen-fueled automotive engines.

PNNL is working with commercial manufacturers of fuel injectors, but additional research is needed before specific engineering changes can be suggested in regard to the materials, the lubrication methodology, or the injector designs. Thus, further commercialization of new injector technology must be viewed as a longer-term outcome of this preliminary work.

In addition, results of this research were presented at a symposium on "Materials for a Hydrogen Economy," The Metallurgical Society, Pittsburgh, 2005.

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